Stratigraphic and Geoacoustic Characterization of the Outer New Jersey Shelf

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LONG-TERM GOALS

As a participant of the ONR Shallow Water Acoustics experiment to be held on the outer New Jersey shelf during the summer of 2006 (SWA06), the long term goal of this project is to understand the interaction of acoustic energy, at both medium and low frequencies, with the seabed.

OBJECTIVES

The objectives of this work are to (1) incorporate existing geological, geophysical and geoacoustic data into a seabed properties model applicable to the SWA06 experiment region, and (2) geologically interpret additional chirp seismic data to be collected as part of SWA06 (Altan Turgut, PI), and incorporate into existing interpretation based on analysis of the ONR Geoclutter program.

Expected products include:

(1) A structural/stratigraphic model of the subbottom, along primary acoustic propagation pathways planned for the SWA06 experiment and regionally as possible with existing and newly collected chirp seismic data.

(2) A geologic interpretation of the regional stratigraphy based on both new and existing chirp seismic data and available ground truth information. This interpretation will focus on the transition from "outer shelf sediments" to "outer shelf wedge" that spans the intervening region between Areas 1 and 2 (Figure 1).

(3) A geoacoustic rendering of the structural model based on predictive relationships between such properties and the geologic interpretation. Available physical property measurements will be used to constrain such relationships.

APPROACH

Seafloor and subseafloor data readily accessible to the PI (Figure 1) are listed below:

(1) Swath bathymetry and backscatter data were collected in 1996 as part of the STRATAFORM program (Goff et al., 1999) and more recently as an unexpected add-on to the Geoclutter program. The backscatter data derived from 95 kHz acoustic frequency. Ground truth data demonstrate that, in this

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region, these data are primarily responsive to the coarse content at the seabed (Goff et al., 2004). Combined analysis with chirp data has also revealed how the seabed morphology can be used to infer the locations of significant seabed erosion (Goff et al.,2005).

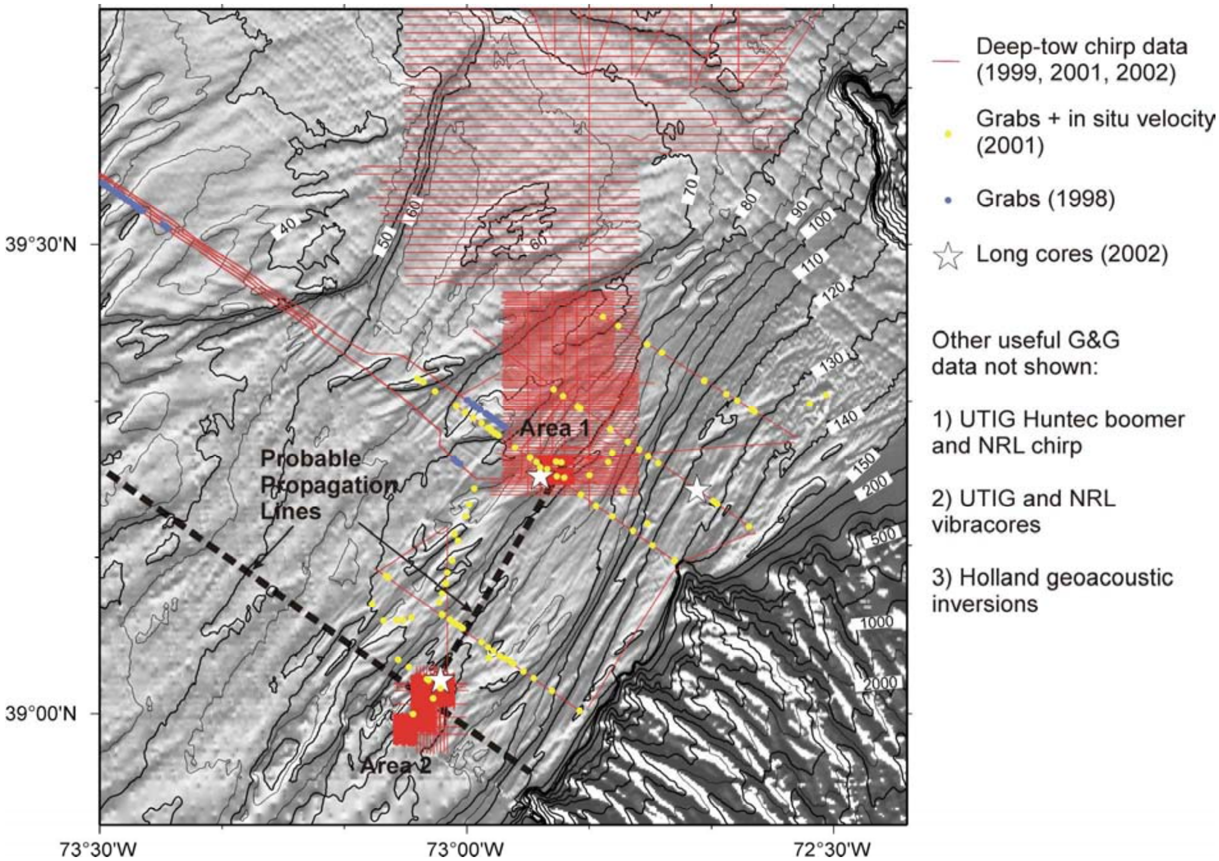

Figure 1. Location of important seabed data and samples, superimposed on bathymetric map of the NJ outer shelf.

(2) Chirp seismic reflection data were collected in 2001 and 2002 for the Geoclutter program (Nordfjord et al., 2004; Gulick et al., 2005). These data have been interpreted structurally (Figure 2). Furthermore, along main dip transects of the 2001 data set, Dr. S. Schock (FAU) has derived seafloor impedance values for 1-4 kHz data (Goff et al., 2004).

(3) Grab samples were collected as part of both the JOI site survey augmentation (Goff et al., 2000) and the geoclutter program (Goff et al., 2004). These samples have been analyzed for grain size distribution.

(4) At the locations of the 2001 grab samples, measurements of in situ velocity at 65 kHz were collected by colleagues at the University of New Hampshire. These values were shown to be correlatable to the mean grain size determined from the grab samples and to the seafloor impedance values derived from the chirp data (Goff et al., 2004).

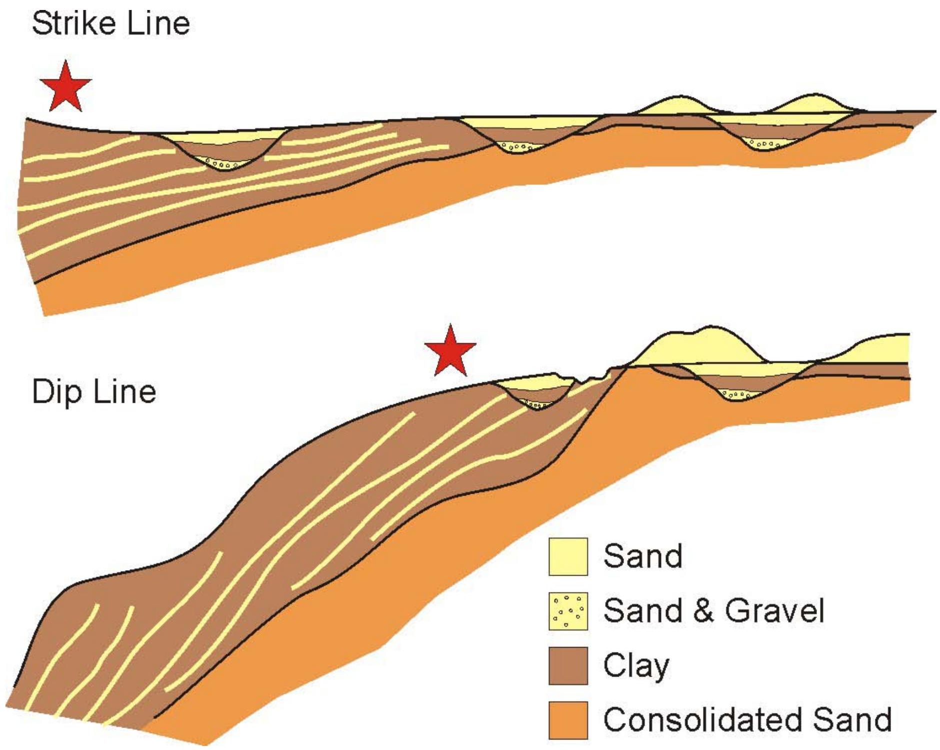

Figure 2. Conceptual drawing of primary stratigraphic units and their relationships along the primary propagation pathways for the SW06 acoustic experiment. Red star indicates the center of the experiments at Area 2 (see Figure 1).

(5) Three long cores were collected in 2002 using the AHC-800 drilling system. These cores are located within the chirp seismic data. They were analyzed for geologic structure and logged for the geoacoustic properties of velocity, density (Figure 3; Nordfjord et al., 2002).

Additional important data sets that may be helpful and would likely be accessible to the PI include:

(1) Huntec boomer seismic data and vibracore results from the 1993 UTIG effort sponsored by ONR (e.g., Buck et al., 1999; Duncan et al., 2000). Utilizing these data will require document and record retrieval and reformatting of older digital seismic records.

(2) Chirp seismic data and vibracore results from the 2001 NRL site characterization as part of the SWAT experiment.

(3) Geoacoustic inversion results conducted by Charles Holland (ARL Penn State) at various locations within both Areas 1 and 2 (Kraft et al., in press).

The primary objective of this proposal is to develop a structural model of the seabed and subsurface along the SWA06 propagation pathways, and to populate that model with measured and predicted geoacoustic properties. The structural model will be based upon the interpreted seismic horizons derived both from existing and to-be-collected chirp or boomer seismic data. Most of the existing data have been interpreted by UTIG colleagues, and exist, along with seismic data, within Geoquest (a

commercial seismic interpretation software package) data bases that reside at UTIG. Some in-house processing expertise will be required to merge the available data into a single data structure for a complete synthesis.

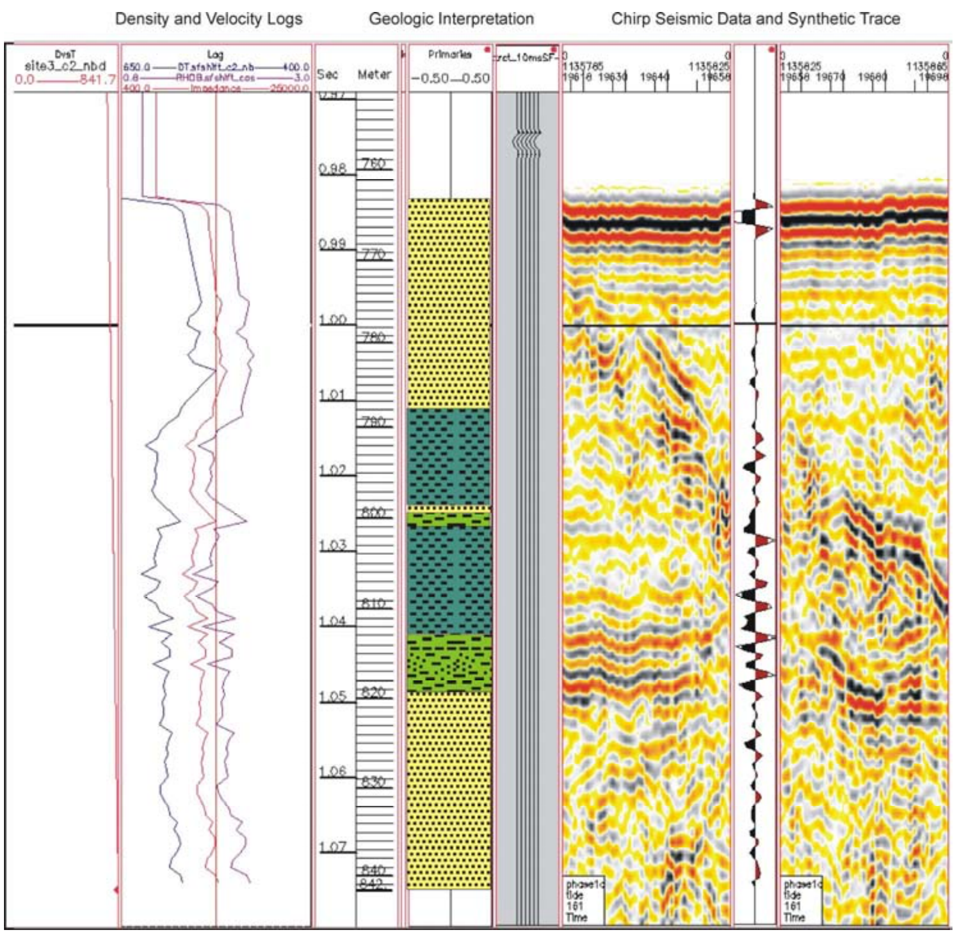

Figure 3. Analysis of Core 3, in Area 1, including density and velocity logs, geologic interpretation (yellow – sand; green = interlaminated mud and sand; aqua = mud), and comparison of synthetic seismic trace, derived from log, with actual chirp data.

The expected SWA06 propagation paths do no always lie along existing chirp track lines. Dr. Altan Turgut of NRL has been contracted to conduct a chirp survey to compliment the available data as needed to cover such gaps in coverage. The PI will collaborate with Dr. Turgut in this survey work. He will also merge that data with the UTIG Geoquest seismic data base for this region (again employing in-house seismic processing expertise), and interpret the seismic horizons seen in the new data in a manner consistent with the previous structural interpretation.

The new chirp data should provide an important geologic product: a structural connection between Areas 1 and 2. Although proximal, the two areas differ in their stratigraphic architecture in a number of important ways. In particular, Area 2 exhibits a thick (nearly 20 m) laminated sequence between the regional "R" reflector and the base of the Holocene sand sheet (or "T" reflector), dipping seaward as part of the "outer shelf wedge" (Figure 2). In Area 1, however, although it is at the same water depth, the sediments between "R" and "T" are much thinner (~5 m at most), flat lying and not well-laminated.

Gulick et al. (2005) interpret the latter sediments as an older unit than the outer shelf wedge ("outer shelf sediments"; Figure 2). The transition between these two units represents a critical structural boundary, and a centerpiece of an hypothesis forwarded by Gulick et al. (2005) for the deposition of Pleistocene sediments as a prograding wedge deposited during the lowering of sea level. From the acoustics standpoint, this hypothesis would have important implications for predicting outer shelf sediment properties in many parts of the world (Kraft et al., in press). The additional chirp data to be collected by Dr. Turgut will of necessity focus closely on this structural transition, and thereby provide additional constraints by which to test the Gulick et al. (2005) hypothesis.

Populating any structural model with geoacoustic properties will pose a significant challenge, given the constraints on collecting new ground truth data for the SWA06 project. Physical property measurements, of course, will be used as much as possible. These include: *in situ* measurements at the seabed, core logs, geoacoustic inversion (Holland experiments), and impedance values estimated from chirp seismic data. However, available measurements are limited, particularly along the planned dip and strike lines for the SWA06 experiment (heavy dashed lines in Figure 1), and also particularly at depth below the seafloor. Some form of prediction will be required. The expectation here is that the geologic interpretation of the stratigraphic structure will guide the prediction. Guided by available ground truth and inference from chirp seismic, the PI will, in close collaboration with Dr. Turgut, seek to formulate geoacoustic model for the primary geologic units that takes into account spatial variability (both laterally and with depth) as well as mean properties. This model will then form the basis for filling the structural model with geoacoustic properties.

WORK COMPLETED

Turgut and Goff successfully completed the SW06 chirp survey in July of 2006. The survey utilized the NRL-owned Edgetech 1-16 kHz chirp system during a 9-day cruise aboard the *R/V Sharp*. Planned survey lines are displayed in Figure 4, along with locations of the primary acoustic deployment. Two priorities were identified for the planned track lines: (1) along primary acoustic propagation pathways for SW06 experiment (phase 1), and (2) a regional grid survey (phase 2) to enable the SW06 region to be placed within the geologic and stratigraphic context of our understanding of Areas 1 and 2.

Despite some technical difficulties with the main tow cable in the beginning of the survey, we successfully surveyed all the phase 1 track lines and all but three of the phase 2 lines. The actual ship's navigation is displayed in Figure 5, and an exampl chirp seismic section is presented in Figure 6. These data are presently being processed for interpretation by both Turgut and Goff.

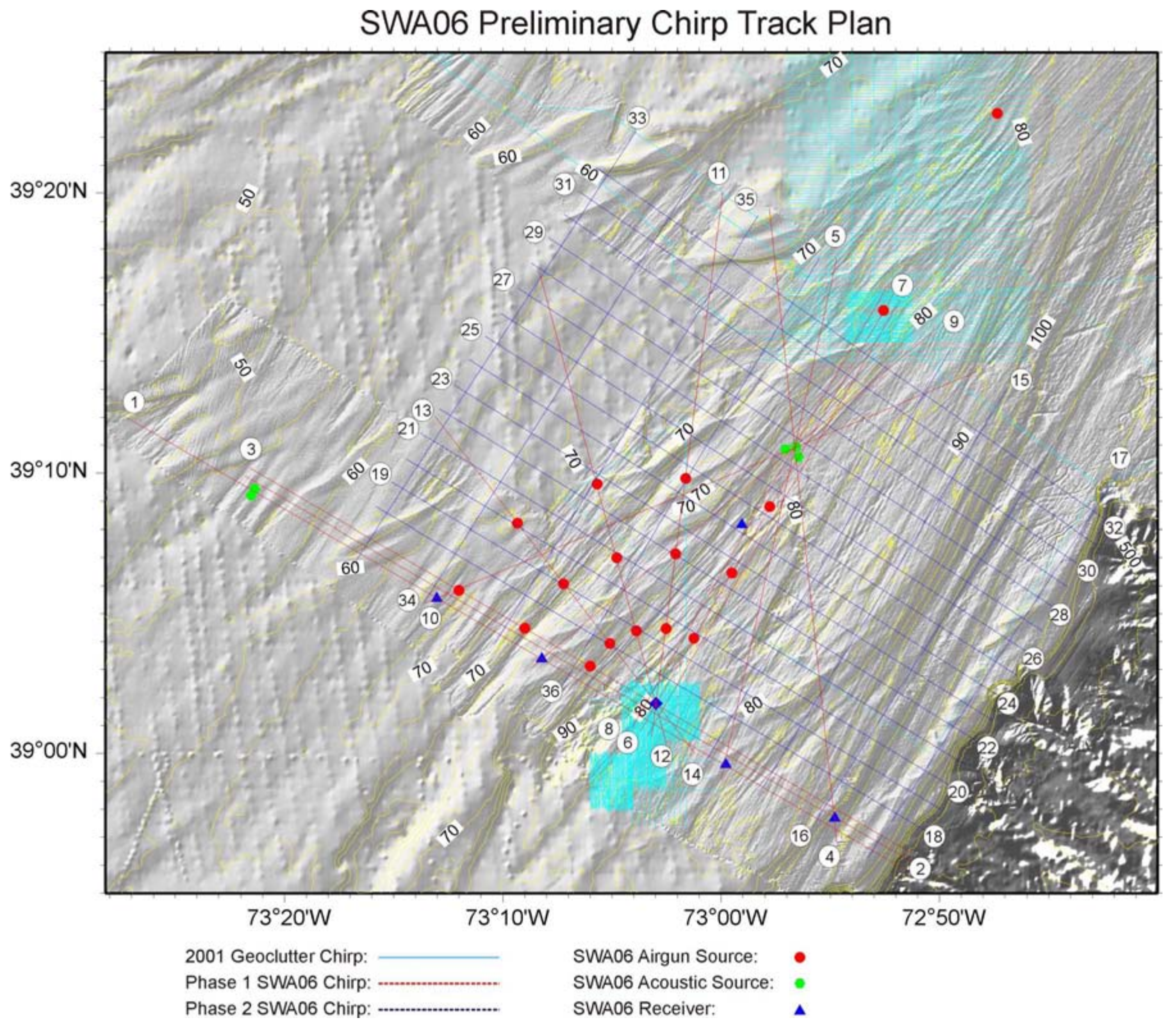

Figure 4. Planned track lines for the SW06 chirp seismic survey (phases 1 and 2), along with previous chirp data (Geoclutter chirp lines) and mooring positions for the acoustic experiment. Circled numbers are track line identifiers. Underlying image is artificially sun-shaded bathymetry (illuminated from the north), with bathymetric contours in meters.

RESULTS

Scientific results have not yet been generated for this project. Data have just been collected and are in the process of being interpreted.

IMPACT/APPLICATIONS

The merged bathymetry and backscatter data will be a direct benefit to acoustic and oceanographic modelers working for the SWA06 project.

RELATED PROJECTS

The ONR Geoclutter, STRATAFORM and Uncertainty in the Natural Environment projects have provide significant data and modeling inputs for this project.

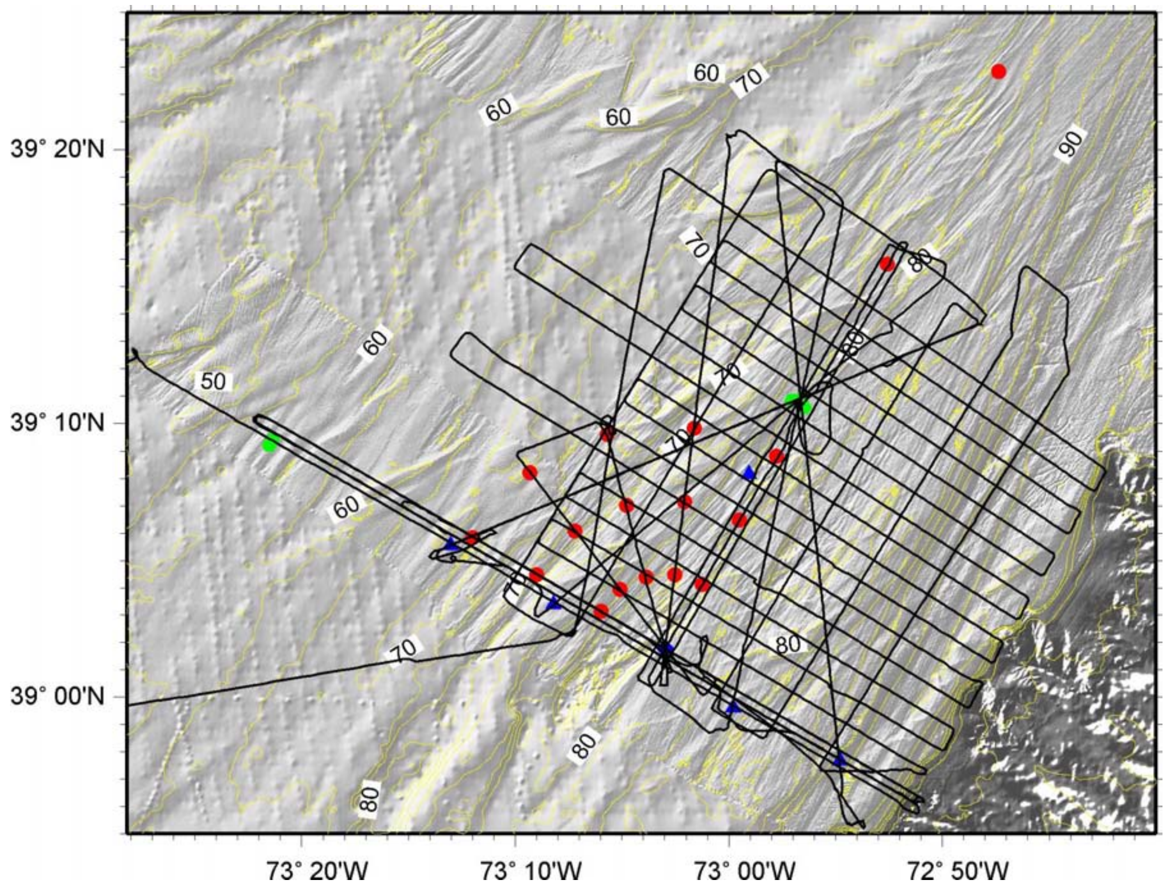

Figure 5. Actual ship navigation for the SW06 chirp experiment.

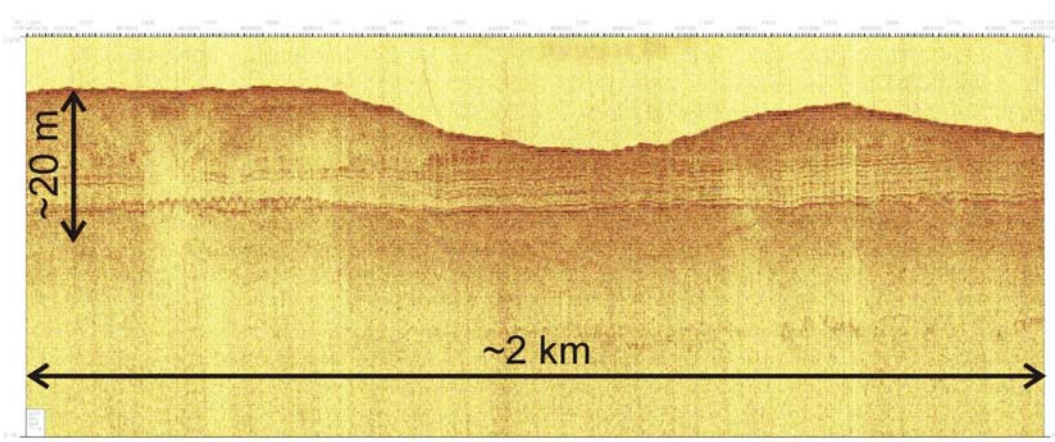

Figure 6. Example of data from the SW06 chirp survey. This is a dip line in Area 2.

REFERENCES

Buck, K. F., H. C. Olson, J. A. Austin Jr., Paleoenvironmental evidence for Latest Pleistocene sea level fluctuations on the New Jersey outer continental shelf: combining high-resolution sequence stratigraphy and foraminiferal analysis, *Mar. Geol.*, *154*, 287-304, 1999.

Duncan, C. S., Late Quaternary Stratigraphy and Seafloor Morphology of the New Jersey Continental Shelf, PhD. Thesis, University of Texas, 222 pp, 2001.

Duncan, C. S., J. A. Goff, J. A. Austin, and C. S. Fulthorpe, Tracking the last sea level cycle: seafloor morphology and shallow stratigraphy of the latest Quaternary New Jersey middle continental shelf, *Mar. Geol*., *170*, 395-421, 2000.

Goff, J. A., D. J. P. Swift, C. S. Duncan, L. A. Mayer, and J. Hughes-Clarke, High resolution swath sonar investigation of sand ridge, dune and ribbon morphology in the offshore environment of the New Jersey Margin, *Mar. Geol*., *161*, 309-339, 1999.

Goff, J. A., H. C. Olson and C. S. Duncan, Correlation of sidescan backscatter intensity with grain-size distribution of shelf sediments, New Jersey margin, *Geo-Marine Letters*, *20*, 43-49, 2000.

Goff, J. A., B. J. Kraft, L. A. Mayer, S. G. Schock, C. K. Sommerfield, H. C. Olson, S. P. S. Gulick, and S. Nordfjord, Seabed characterization on the New Jersey middle and outer shelf: Correlability and spatial variability of seafloor sediment properties, *Mar. Geol*., *209*, 147-172, 2004.

Goff, J. A., J A. Austin, Jr., S. Gulick, S. Nordfjord, B. Christensen, C. Sommerfield, and H. Olson, C. Alexander, Recent and modern marine erosion on the New Jersey outer shelf , *Mar. Geol., 216*, 275-296, 2005.

Gulick, S. P. S., J. A. Goff, J. A. Austin, Jr., C. R. Alexander, Jr., S. Nordfjord, and Craig S. Fulthorpe, Basal inflection-controlled shelf-edge wedges off New Jersey track sea-level fall, *Geology*, *33*, 429-432, 2005.

Kraft, B. J., I. Overeem, C. W. Holland, L. F. Pratson, J. P. M. Syvitski, and L. A. Mayer, Stratigraphic model predictions of geoacoustic properties, *IEEE J. Ocean Eng*., in press.

Nordfjord, S., S. P. Gulick, J. A. Austin Jr., J. A. Goff, C. S. Fulthorpe, Late Quaternary incisions and related shallow subsurface stratigraphy on the New Jersey mid-outer shelf: preliminary results from ultra-high resolution chirp sonar images - part I, *Eos Trans. AGU*, *83*, Fall Meet. Suppl., Abstract OS71C-0299, 2002

Nordfjord, S., J. A. Goff, J. A. Austin, Jr., and C. K. Sommerfield, Seismic geomorphology of buried channel systems on the New Jersey outer shelf: Assessing past environmental conditions, *Mar. Geol*., 214, 339-364, 2005.